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Chief Contract Branch LO/PD

Chief, Engineering Division, OC

Contract [redacted]
Request for Estimate on Potential Task VI

1. The attached outline describes a task for the evaluation of a proposed type of radio locating system. It is requested that the outline, to be known as Task Order VI, Contract [redacted], be forwarded to the firm of [redacted] 50X1
[redacted] and that this firm be asked to submit a cost and time estimate for the services and equipment involved. 50X1

2. It is requested that the Contractor be notified that the project officers for this task are [redacted] alternate. 50X1

3. This estimate should be forwarded to the Engineering Division, OC, not later than 4 March 1955.

[redacted] 50X1

Attachment: As Above
3 - Contract Officer
2 - OC-E - (Task VI, [redacted] (OC-E/SAG) 50X1
Distribution:
Orig & 1 - Addressee
3 - OC-E - (Task VI, RD-35)
(OC-E/SAG)
(OC-E/Chrono)

ORIG: OC-SP/A [redacted] (10 February 1955) 50X1

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TASK VI

EVALUATION OF PROPOSED RADIO LOCATING SYSTEM

PROBLEM:

To evaluate a proposed system for radio location (Attachment A). This task will be concluded with the submission of a final report, setting forth the findings of the Contractor. The principle of this system is the determination of the bearing of a radio station by the simultaneous reception of signals from this station at three controlled sites. Bearings will be determined by the simultaneous recording of a signal at the three sites, and by measuring the time difference of reception of the same signal element at the three positions.

SPECIAL CONDITIONS:

Phase 1

1. The Contractor, in conjunction with the properly designated Technical Representative of the Contracting Agency, will plan, lay out, and design an initial system in detail, including the preparation of a complete bill of materials. Such equipments as may require changes or modifications will be listed. Such equipments as may have to be developed, designed, and constructed will be listed. It is clearly understood that the work as outlined under this paragraph will require an appreciable amount of engineering design. The Contractor is to submit not later than the fifth of each month a progress report summarizing the work done during the preceding month.

2. The Contractor is to prepare a cost estimate of all the materials which will be completed under paragraph 1, and upon approval by the Government of the list of equipment, the Contractor shall take steps to purchase, modify, or build the required equipment.

Phase 2

1. Delivery of the equipment shall be made to the plant of the Contractor, where it will be assembled and tested. While in the Contractor's plant, all necessary delay measurements shall be made on the equipment prior to its installation. The Contractor is also to make a closed circuit test of all equipment functioning as a three station system. Operating procedures and an overall check of the system are to be obtained from this specific test.

2. It shall be the responsibility of the Contractor to adequately install the equipment to insure that it is in correct operating condition and that all three sites are operating identically. This is a prime requisite of the evaluation proceedings. These three sites are located in the Washington area, the Contractor's plant, and in the vicinity of Williamsburg, respectively.

3. On completion of the installation phase of this evaluation, the Contractor shall operate the State College site in this test set-up. Government personnel will operate the equipment at the two remaining sites.

4. The Contractor will be responsible for the overall maintenance of the system.

5. The Contractor will provide consulting services throughout the duration of this evaluation, since it is anticipated that changes and/or modifications of the equipment or the method of operation of the system may be found desirable.

6. The Contractor will cooperate closely with the Technical Representative during this work, and it is required that the Contractor issue monthly progress reports as previously mentioned.

Attachment

ATTACHMENT A

PROPOSED SYSTEM FOR RADIO LOCATION

GENERAL:

1. The proposed system for radio location is physically located at three sites, one of which is a control station and two are out stations. This system consists of three parts. The first part is a method of intercepting the signal that is to be located. This would consist of normal antennas and radio receivers, etc. The signal will be displayed on one half of a double beam oscilloscope. The second part of the system is the method for alerting the out stations so that they will be operating against the same target at the same time. This system can consist of a radio circuit, a land line, or the public mail--whichever is more suitable to the problem at hand. The third part of the system is the timing circuit. It is the function of this circuit to provide a common, comparable marker interval system for comparison and timing purposes. By utilizing this portion of the system it is possible to determine the time difference of arrival of the radio signal at the various stations of the locator system.

TIMING SYSTEM:

2. The proposed system operates in the following manner. The reference signal is generated by a frequency standard such as the General Radio frequency standard. This standard and the associated equipment are located at the control station. The output of the frequency standard is passed through a wave shaping circuit operated by a manual gate in order to present the timing signal on demand. The wave shaping circuit renders the standard frequency shorter in rise time so that greater timing accuracy is achieved. The wave shaping circuit, thus, would limit, clip, and differentiate the sine wave signal from the frequency standard, delivering a series of rather sharp pulses. These pulses would then be passed to a vacuum tube keyer which would key a C. W. radio transmitter. The wave shaper and the vacuum tube keyer equipment would normally be expected to be constructed by the Contractor, and the transmitter should be purchased. A transmitter having a reserve power of about 500 to 1000 watts peak power should be adequate for the purpose, although it may be practical to operate the system with considerably less power most of the time.

3. Branching off from the wave shaper circuit ahead of the keyer unit is a circuit leading to a counter chronograph, specifically to the ON control of this counter. Depending upon the reaction of the

counter chronograph

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counter chronograph to the reception of successive ON pulses, once it has initiated action, it may be necessary to devise circuitry to eliminate all but the first pulse of the timing wave train from the input to the counter chronograph. If this is found to be necessary, the properties of fired gas tubes, especially their low input impedance, should be helpful. Of course, the DC plate supply will furnish a manual reset feature desirable. This could be combined with the actuating gate for releasing the timing signal.

4. Local circuitry must be provided at the control station to impress the timing wave train upon one beam of a dual beam cathode ray oscillograph.

5. The actuating control for the timing gate should operate in the release position after actuation. The actuate position of the control can then be used for performing two functions: (1) Turning on the motors of the scope cameras and (2) Resetting local the lockout on the counter chronograph ON circuit successive pulse eliminator. This then would set up the equipment to receive the actuate signal.

6. At the OUT station the timing signal is delivered to the dual beam oscilloscope the same as at the control station. The timing signal is also delivered to a successive pulse eliminator circuit, with a manual reset, thence to a keyer tube to a transmitter similar to the one transmitting the timing signal. This transmitter could undoubtedly be smaller in capacity than the one at the control station because of the smaller duty cycle. This single pulse that is transmitted back to the control station is used to turn off the counter chronograph. The function of the successive pulse lockout circuit at the out station is to keep the out station off the air as much as possible. In this manner they do not transmit a train of pulses, only a single pulse at random intervals. The manual reset also provides another function of the system. It can indicate to the control station operator the fact that the out station operator for some reason or other is not able to cooperate. This is indicated at the control station by failure of the chronograph to shut off. This is a fail safe feature of the system, since in any event, no information can be used from the system if one of the counter chronographs fails to indicate.

CAMERA CONTROL:

7. It is anticipated that the camera recording system for this radio locator would be Fairchild Oscillorecord Cameras on Dumont dual beam scopes. Various simple systems can be utilized to turn on the camera motors, such as a resonant reed relay at the out station and a tone generator at the control station. The cameras must be provided with a timer which will allow them to run for a definite interval of time and then shut off.

UNDETERMINED DESIGN FACTORS:

8. Certain factors are best determined during the course of this evaluation or in the initial set-up when the complete equipment becomes available. One of the chief of these factors is the frequency of the timing signal to be transmitted. Another closely related factor is the speed and length of film run out during any one individual shot. The value and variability of the delays which the timing signal will encounter in the equipment itself is unknown and must be determined prior to attempted operation. The power actually required for the transmitters must be determined.

A POSSIBLE METHOD OF LOCATING AN UNKNOWN TRANSMITTER BY INVERSE LORAN

If we assume that radio waves travel at the speed of light, we find that 5.38μseconds is required for a radio wave to travel one mile.

The system proposed here uses three receiving stations and a transmitter at an unknown location, in contrast to loran in which three transmitters are at known locations and the receiver is at the unknown location.

The proposed system requires that some identifying characteristic with respect to time be transmitted by the transmitter at the unknown location. This may be the turning on or off of the carrier of the transmitter, or any other characteristic of the signal that can be identified without question.

The two slave receiving stations are separated by a distance of approximately 150 miles from the third receiving station which acts as control station. The time of arrival of the identifiable characteristic at each of the three receiving stations is noted, with respect to the same time reference. In order to obtain the same time reference at each of the three stations it is necessary for the control station to transmit a time signal to each of the slave stations. The time signal received at the slaves must be corrected to compensate for the time delay encountered in transmitting the time signal from the control station to the slaves.

One method of instrumenting a chain of stations to enable this type of operation is shown in the attached block diagram.

Each of the three stations is equipped as follows:

1 - Berkeley Model 5510 Universal Timer
1 - Collins 32V3 Transmitter (or equivalent)
1 - Hammurland SP-600 with crystal high frequency oscillator
1 - Collins 51J3 communications receiver
1 - Start or Stop signal generator

The Berkeley Universal Timer is a Time Interval Meter including a crystal controlled time base, an electronic gate, direct coupled start and stop input circuits, and six decimal counters. The signals from the start and stop circuits open and close the electronic gate and allow the time base frequency to be applied to the cascaded decimal counting units. The number of pulses passed through the gate during the time it is open is registered on the decades. The elapsed time is read directly in microseconds when a one megacycle crystal controlled time base is used.

The Collins 32V3 transmitter is recommended because it is a highly reliable unit with reasonable power. It is used for the communications link between the receiving stations.

The Hammurland SP-600 receiver is recommended for the receiver in the communications link because a crystal controlled high frequency oscillator is available and will eliminate mis-tuning of this receiver and will provide very reliable service.

The Collins 51J-3 is recommended for the receiver to be used to pick up the unknown because of its calibration accuracy which will help in the accurate selection of the unknown signal.

The start and stop signal generators are needed tocontrol and calibrate the system. The start signal generator is located at the control station. The stop generators are located at the slave stations.

To calibrate the timers at all three redeiving stations, B - the control station, works with first one slave and then the other in the following manner. B. transmits a start signal which starts his timer and upon receipt at A, A's timer starts. A noting that his timer has started transmits a stop signal which stops his timer and upon receipt at B stops that timer. The timer at B now reads a value which is largerthan the reading at A. The difference in these readings divided by two is the delay time for the path.

B now conducts the same calibration procedure with C. The timers at A and C are now set so that they start to count not from zero but from a number which has been set into the counter. This number is the path delay time in microseconds as determined in the calibration procedure outlined above.

The Collins receivers at all three stations are tuned to the transmitter at the unknown location. The switches are all turned to calibrate, which connects the output of these receivers to the stop channel of the timers. The start channel of B's timer is connected to the start generator in parallel with the input to the communications link transmitter. B transmits the start pulse which starts his counter and upon arrival at A and C starts their counters. All counters should now be reading exactly alike since the signal arrived at each station the same number of microseconds after starting the counter at B as the number which was preset in the A and C counters.

All three counters will stop upon receipt of the signal from the transmitter at the unknown location. The difference in the readings at the three stations can be used much in the same manner as a navigator uses his loran data to find the hyperbolic lines of position.

Many errors are possible in a system of this sort. Some are differences in path lengths due to changing ionosphere heights, erros in calibration, inability to use short pulses for start and stop signals, delay times in equipments which may or may not be constant and the inability to control the transmitter at the unknown location.

[redacted] 15 Feb 1955

Description

of a

Proposed Radio Location System

GENERAL

The system here proposed operates to locate the source of a radio transmission by measuring the time difference of arrival of the given signal at three separate receiving locations. ~~As an overall system it is~~ This system can be considered as constructed of three information channels:

1. An Alert Channel
2. A signal Channel
3. A timing Channel

The alert channel serves to activate the three locations to a given target whose location is desired. This alert channel, depending on the specifics of the network, can be anything from a letter to a complete radio teletype network. The only requirement of this information channel is that it be capable of directing the netowrk as rapidly as the situation demands.

The signal channel serves to deliver the agreed upon signal to the recording/measuring equipment and is completely straightforward.

The timing channel is unique to this system, at least in detail and will be the subject of somewhat more detailed description.

The purpose of the timing channel is to make available to all three stations one time standard to which ~~all the~~ the ~~received~~ signal received at each of the three points may be compared.

The timing channel operates in the following manner: The clipped and differentiated signal from the ~~standard~~ time standard is transmitted for a short while, ~~manually~~ by manually operating a switch. This signal is transmitted from one of the stations to the other two stations in the network. The station

Possessing the time standard (and other equipment) is known as the "control" station. At the ~~master~~ control station the transmission of the timing signal is concurrent with ~~the~~ starting Potter [illegible]/450 [illegible] chronograph ~~a time interval meter~~, which is shut off by the out stations returning a pulse from the timing series back to the control station. This series of timing pulses is recorded -- together [illegible] with the signal -- on 35 mm film from a Dumont model ___ dual beam oscilloscope. Using a Fairchild [illegible] This recording is done at all three stations. The film is later compared at one central point where the time delay figures are known. Presumably the control station.

DESCRIPTION

of a

SYSTEM FOR RADIO LOCATION

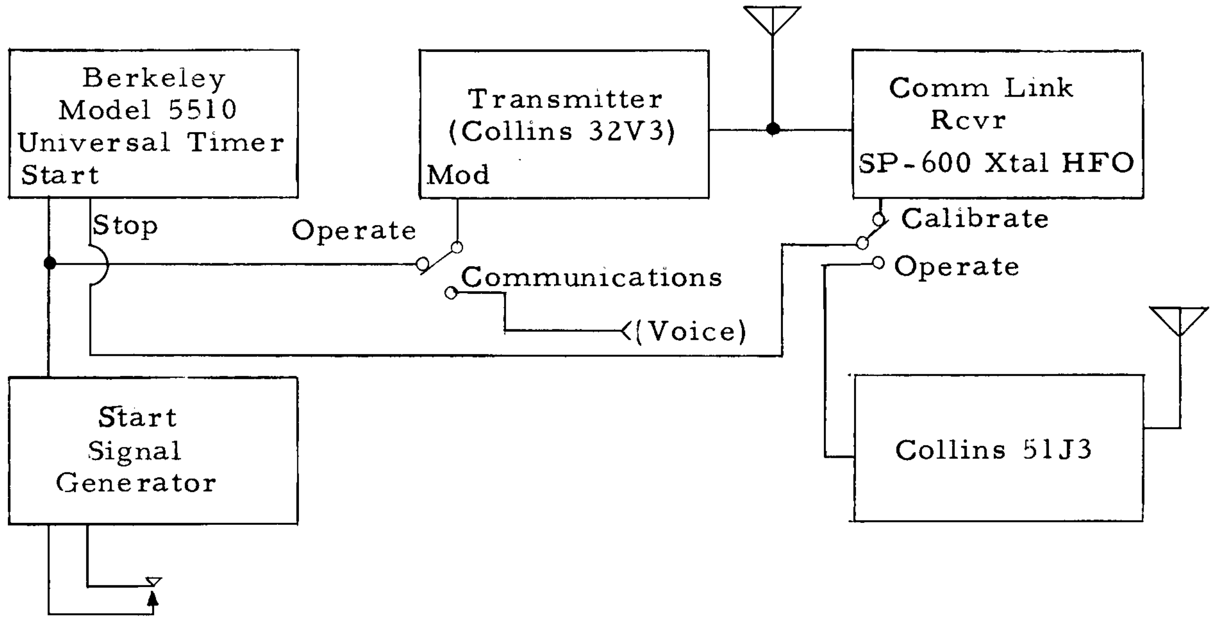
1. This system, known as an ~~inverse~~ inverse Loran system has three major divisions. A) The signal reception Channel system

B) The timing channel

C) The alerting channel.

The alerting channel is a communications channel that serves the purpose of directing the location network against a given target at the time in question. It is intended that the alerting network shall operate in a "Fox" manner -- just it is anticipated that there will be no special problems connected with this channel. The signal channel is also a straight communications or intercept channel which is directed by the alerting channel. This channel presents even less of a problem than the alerting channel. The timing channel is the portion of the location system that attention must be directed towards.

Control Station "B"



Stations "A" and "C"